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Response to FCC IB Docket No. 17 -16

Hexagon is a leading global provider of information technologies that drive productivity and quality across geospatial and industrial enterprise applications. Hexagon Positioning Intelligence (HPI) provides satellite positioning and correction solutions for land, sea and air. HPI encompasses NovAtel based in Calgary, Canada, Antcom based in Torrance, California, NovAtel America based in Houston, Texas, and Veripos also in Houston, Texas. NovAtel and Antcom design and manufacture Global Navigation Satellite System (GNSS) receivers and antennas, delivering global satellites positioning products recognized for technical innovation, unsurpassed quality and industry leading customer support. Veripos provides GNSS correction services utilizing Mobile Satellite Service (MSS) L-Band services. Hexagon Positioning Intelligence GNSS equipment and services are utilized in numerous industries in the USA and are generally private labelled. Major industries served are aerospace & defense, marine exploration & operation, agriculture, autonomous and robotic applications, geomatics & surveying, airborne and ground mapping, and timing for critical national infrastructure.

All comments within this letter are with respect to GPS usage and MSS. No comment is provided on Aeronautical Radio Navigation Service (ARNS), Earth Exploration Satellite Service (EESS), or Space Research Service (SRS) interoperability.

We have no objections to the request by the European Commission (EC) for a waiver of the Federal Communication Commission's licensing requirements to permit receive only earth stations to operate with signals of the Galileo Radio Navigation Satellite Service system. Galileo signals need to be compatible with current and planned operations in adjacent and nearby spectrum. We are not aware of, and have not experienced, any interference or interoperability concerns raised by Galileo signals with Global Positioning System (GPS) signals, or with any other services authorized to operate in adjacent or nearby bands.

In the following text, we will respond to the specific requests for comment in Public Notice DA 17-18, IB Docket No.17-16.

Galileo Signals and RNSS Allocations

To clarify the Galileo signal composition, the best reference is the Galileo Signal in Space Interface Control Document and Open Service Definition Document at https://www.gsa.europa.eu/library/technical-documents (released December 2016).

E1 Signal

We agree with the assessment that there should not be any electromagnetic compatibility issues with GPS L1 or L1C signals. We are not aware of, and have not experienced, any interference concerns raised by E1 with respect to any other services authorized to operate in adjacent or nearby bands, including 1525-1559 MHz. We have receiver designs that concurrently receive signals in the 1525-1559MHz band, as well as GPS L1 and Galileo E1. and our future devices will be compatible with ancillary terrestrial component (ATC) signals.

E5 Signal

We agree that E5 transmissions do not raise any interference concerns or electromagnetic compatibility issues with respect to GPS L5 or GPS L2.

Potential Impacts relating to Galileo Receivers and Non-Federal Operations

NovAtel's commercial GNSS receivers have been designed to track Galileo (E1 and E5) signals in addition to GPS (L1, L2, with L5 or MSS reception) and GLONASS (L1 L2) since OEM628 was introduced in 2010. Including Galileo signals does not materially change the design of a multi-frequency receiver. The intended pass band of the receiver must include the desired signals. There are a variety of design choices on how to accommodate the wider pass band, which can impact material costs, receiver size, power consumption, and out of band rejection performance depending on which of these parameters is prioritized. A high precision receiver that supports GPS L1, L2 and L5 will have the same design tradeoffs as one that supports Galileo E1 and E5. The addition of Galileo E6 extends the passband beyond what GPS multi-frequency support requires, and requires specific design choices to simultaneously support it and E1, E5, L1, L2 and L5, as well as maintain the same performance parameter prioritization.

Operations with the Galileo E1 signal

We agree that receivers that operate with E1 and GPS are electromagnetically compatible and interoperable, and that Galileo receivers should not raise any concerns with transmitter operations in the 1559-1610 MHz band.

As mentioned above, designing a receiver to support E1 does not materially change its design or performance. While most receivers can operate in Galileo only mode, the general use case is multi-constellation operation with a single antenna for all signal types. The choice of which signals are used in the PNT solution is done within the software running onboard the receiver. Again, the general use case is to allow all signals into the solution, but the software can be configured to exclude particular signals if desired. The output format typically specifies what constellations contributed to the solution – as in NMEA 0183 (GP prefix for GPS only, GL for GLONASS, GA for Galileo and GN for combined solutions, see https://www.nmea.org/content/nmea_standards/nmea_0183_v_410.asp), and in most manufacturer's proprietary output formats as well. Running concurrent, separate PNT solutions is also possible. The amount of variation in the front ends for E1 devices is similar to the amount of variation in the front ends of L1 devices. It depends on the design priority and the intended use of the receiver, but there is no more variation for E1 than for L1.

With respect to how an E1 receiver could be designed to ensure electromagnetic compatibility with operations in adjacent or nearby bands, it should be remembered that an E1 receiver is extremely similar to an L1 receiver and is in all probability the same receiver and the techniques used for one constellation apply to the other (Gao, F., Kennedy, S., (2016). *Demonstrated Interference Detection and Mitigation with a Multi-frequency High Precision Receiver,* Proceedings of ION GNSS+ 2016, Portland, Oregon).). For future designs we have no concerns about interference from proposed adjacent band ATC operations.

Operations with the E5 and E6 signals

For receivers that operate with E1 as well as E5 and E6, having a common antenna is typical and then within the receiver there may be separate RF paths for the upper and lower L-bands.

The design assumptions about the RF environment are based on the signal in space interface control documents for all constellations (GPS, GLONASS, Galileo and BeiDou), as well as approved uses in adjacent or nearby bands at the time of the design.

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Public Interest Benefits and Other Considerations

Service availability, accuracy, and reliability

Reception of Galileo signals will improve the availability of PNT solutions, particularly for operating environments with obstructions that block the view of the sky, which happens whenever travelling down a city street, following a wall or building, travelling on the lower deck of a bridge, passing under trees or following a tree row, and many other examples commonly encountered in daily life and industrial settings. Having more satellites providing signals that a receiver is capable of receiving greatly increases the number of epochs with a PNT solution of all precision levels, from centimeter to meter level positioning. For example: street level mobile mapping in urban settings; agricultural vehicles operating close to tree rows, close to other implements operating in the same field, or near buildings; construction layout or machine guidance on the north side of an existing building with the southern sky blocked; a truck, taxi or car service driving on the lower deck of a bridge or stacked freeway, either for asset tracking or for navigation/guidance. A continuously available PNT solution is critical for autonomous or semi-autonomous systems. We do not foresee that granting a waiver would have a detrimental impact on GPS service availability, accuracy, or reliability.

Resiliency

The use of E1, E5 and E6 will improve the resiliency of GPS in a number of ways. Firstly, a second constellation can be used to detect spoofing. It may not be able to confirm which constellation is being spoofed, but inter-comparisons can detect that something is not right and alert the user to proceed with caution. Secondly, the signal structure of the Galileo signals may resist interference better than GPS civilian signals. (GPS III will bring the same benefits with L1C.) Finally, it has been recently announced that the Galileo Open and Commercial Services will provide additional authentication capability to prevent spoofing (http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017D0224&from=EN and https://www.gsa.europa.eu/sites/default/files/content/press_releases/pr-gsa-09-03_2017_galileo_commercial_service_implementing_act.pdf).
A GPS solution could be checked against an authenticated Galileo solution in order to improve integrity.

In summary Hexagon Positioning Intelligence and its subsidiaries fully support the grant of the requested waiver.

Michael Ritter

President Hexagon Positioning Intelligence